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# PULLING MACHINES for harvesting FIBER FLAX



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in cooperation with
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# PULLING MACHINES
# for harvesting FIBER FLAX

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## Introduction

Flax was one of the first crops grown by the early colonists in the United States, and it was the principal agricultural fiber crop until the invention of the cotton gin in 1793. The lower cost of cotton soon caused the majority of the flax processors to cease operation, but a small flax industry has persisted throughout the years—first in Michigan, then in Oregon—in spite of adversity.[1]

Stimulated by World War II demand for fiber, the industry reached its peak in 1942 when 12 processing plants were extracting the fiber from the straw produced on 18,000 acres.[2] The postwar slump, caused by the reduction in military requirements for fiber, competition of other crops for the farmers' land, and competition of synthetic fibers and imported flax for the domestic market, resulted in the closure of all the plants except one and the reduction in acreage to 900 in 1954.

In harvesting fiber flax the plants are pulled from the ground rather than cut, in order to obtain longer fiber and as much fiber as possible. Until recent years fiber flax was harvested or pulled largely by hand. Many patents were issued for flax-pulling machines but only a few machines were constructed and used. This was partly because of an abundance of cheap labor in the flax-growing areas of the world and also because the farmer's flax acreage was small and would not justify the purchase of expensive machines. Consequently, the harvesting and processing of flax was done manually by members of the farmer's family.[3]

The rate of harvesting flax when pulled by hand ranged from ⅛ to ¼ acre a day, depending on the physical ability of the individual and the condition and density of the flax crop.

With the trend toward the mechanization of other farm operations and a movement of people from the farm to the city, it became increasingly difficult to get flax hand-pulled.

In 1938, in an effort to improve mechanical processes for handling fiber flax, agricultural engineers of the United States Department of Agriculture started cooperative research work with the Oregon Agricultural Experiment Station at Corvallis. Particular attention

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[1] ROBINSON, B. B. FLAX-FIBER PRODUCTION. U. S. Dept. Agr. Farmers' Bul. 1728, rev., 28 pp., illus. 1940. (See pp. 2 and 3.)

[2] HURST, W. M., NELSON, E. G., HARMOND, J. E., KLEIN, L. M., and FISHLER, D. W. THE FIBER-FLAX INDUSTRY IN OREGON. Oreg. Agr. Expt. Sta. Sta. Bul. 531, 20 pp., illus. 1953.

[3] HURST, W. M. FIBER-FLAX MACHINERY AND PROCESSING OPERATIONS IN OREGON. U. S. Dept. Agr. Cir. 667, 27 pp., illus. 1943. (See p. 2.)

was given to the development of pulling machines for harvesting the crop. Information presented in this publication is the result of that cooperative research.

## Development of Pulling Machines

### Canadian Puller

In 1923 the State Flax Industry (at the Oregon State penitentiary, Salem) imported a flax-pulling machine from Canada (fig. 1). The State penitentiary used the Canadian puller as a pattern and con-

FIGURE 1.—A Canadian flax puller imported by the State Flax Industry in 1923.

structed a number of pulling machines that were used in the thirties. By 1934 the Oregon flax acreage had increased considerably and virtually all the fiber was harvested with mechanical pullers.

The Canadian-type machine was a tractor-drawn trailer-type with a pulling section that consisted of 3 pairs of flat belts. The belts, which were placed on 12-inch centers at the throat, ran up a 45° incline. The gripping force was applied by numerous small spring-loaded rollers spaced along the sides of the pulling throats that pressed the belts together. A 36-inch swath of flax was gripped by the 3 pairs of belts, which lifted the flax vertically out of the ground. The straw was conveyed up the 3 inclined pulling channels and delivered into a binding unit at the rear of the machine. The pulled straw remained in a vertical position until it was bound and discharged at the rear of the puller.

The machine did an excellent job of pulling standing flax, and it formed bundles that compared favorably with hand-formed bundles. However, it was not suited for harvesting flax that was down or lodged, and considerable difficulty was encountered in keeping the machine's many moving parts in a workable state of repair and the flax from wrapping around the small rollers and shafts.

## Belgian Puller

In 1939 a flax puller developed in Belgium was introduced into Oregon by the United States Department of Agriculture (fig. 2). Because of its simple construction and ease of operation, this type of puller became very popular. It is tractor-drawn and has two 18-inch pulling sections—each consisting of straw guides, a rubber-rimmed wheel, and a flat rubber-faced belt. The wheels are tilted backward to approximately a 70° angle with the ground. The belt and wheel run into each other so that straw guided between the wheel and belt is bent forward to an angle of 70° with the vertical and is pulled as the wheel rotates upward, forming a single horizontal layer of flax straw. The flat belts deliver the straw into a horizontal binder located at the opposite side of the puller. The binder forms single-string bundles and deposits them on the ground.

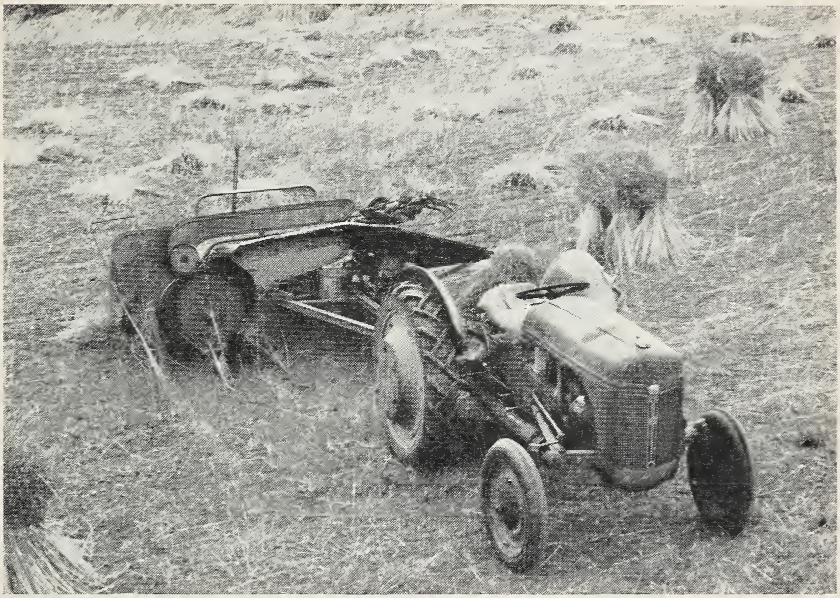

Figure 2.—A Belgian type of flax puller imported in 1939 by the United States Department of Agriculture.

The machine operates with far less difficulty than the inclined-belt type and harvests downed flax surprisingly well. It has a capacity of approximately 1 acre per hour in a 2-ton crop. The main objections to this type of puller are that it often crushes and damages the flax straw in the gripping device and that the root ends of the straw in the bundles are very uneven. In the bacterial retting operation the damaged section of the straw is attacked before the undamaged part, resulting in overretting and a weak section in the processed fiber. The uneven root ends contribute to the loss of straw in deseeding, retting, handling, and scutching, which results in uneven fiber hanks that in turn contribute to spinning losses and irregular-sized yarns; the ragged bundles also contribute to the loss of seed.

## An Early Oregon Puller

A trailer-type puller developed in Oregon in 1941 is somewhat similar to the Canadian puller in that it grips the flax between flat belts that run up an incline so that the flax is lifted out of the ground, and it delivers the flax to the binder with the straw in the vertical position (fig. 3). However, it differs from the Canadian puller in

FIGURE 3.—An Oregon-developed flax puller having a capacity of more than 1½ acres per hour. This machine is a considerable improvement over its predecessors and has been used to pull the major part of the Oregon flax crops since 1950.

that it has 2 pulling throats in the 36-inch pulling width, whereas the Canadian puller had 3 throats.

The Oregon puller is simpler in construction than its predecessor. It has fewer moving parts and larger diameter pulleys. The larger pulleys, which are staggered so that the belt has pulling tension, are used in lieu of many small spring-loaded pulleys; the angle of incline of the pulling belts is greater and the pulling belts are shorter than those of its predecessor. However, the chief objection to this type of puller is that it scuffs the straw and forms ragged bundles. Some difficulty is encountered in harvesting green or weedy flax because the flat belts have a tendency to run off the drive pulleys.

## Fiber-Flax Combine

In 1942–43, the research engineers constructed an experimental fiber-flax combine. It consisted of two 18-inch pulling throats, a rotary-comb deseeder, a double-needle straw binder, and a threshing machine. It would pull the flax, deseed it, tie the straw into double-banded bundles and thresh the seed—all in one operation. The machine was used to harvest flax for 2 seasons and was proved to be mechanically feasible, but it was then abandoned for the following reasons: Its low capacity; its high initial cost, considering the unit would be used only 5 or 6 weeks out of the year; an unbalanced capacity of the component parts (that is, the threshing machine's

capacity was much greater than that of the pulling section); its bulkiness, which made it awkward to maneuver in the field; and the very important fact that the machine could not deseed and thresh the crop until the seed pods had become so dry that the flax had passed its peak quality and the quality was well on the downgrade (fig. 4).

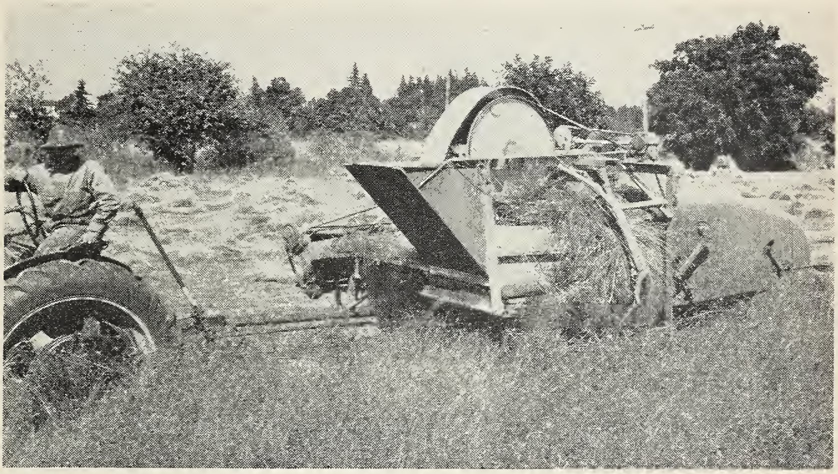

FIGURE 4.—An experimental fiber-flax combine developed on the cooperative research project and abandoned after 2 seasons' use. It pulled, deseeded, threshed, cleaned the seed, and bound the flax with 2 bands into bundles ready for retting.

## Pneumatic-Tire Pullers

Between 1938 and 1945, several experimental pullers were designed and constructed in an effort to develop a flax-pulling machine that would harvest the crop satisfactorily without damaging the straw, yet have a low initial cost and a capacity large enough to harvest the crop economically. One of the first of these pullers was a unit similar in principle to the Belgian machine, but having an 18-inch pulling throat, an automobile wheel, and a 600–16 size pneumatic-tire gripping device. The gripping device consisted of the pneumatic tire and a flat belt that was held against the tire by a series of fixed center steel rollers arranged in an arc around a section of the tire. The gripping force could be increased or decreased by raising or lowering the air pressure in the tire. By gradually raising the air pressure until the force was just enough to pull the flax, damage to the straw could be greatly reduced. This experimental puller was mounted on the chassis of an old automobile that had been altered to steer and run backward. The machine did a clean pulling job but its capacity was low and the initial cost was high and out of proportion to the acreage it would harvest (fig. 5).

In an effort to overcome the low capacity, a triple-throat unit with 400–12 size pneumatic tires was mounted on a tractor so that the flax was pulled on the right side and conveyed under the tractor to

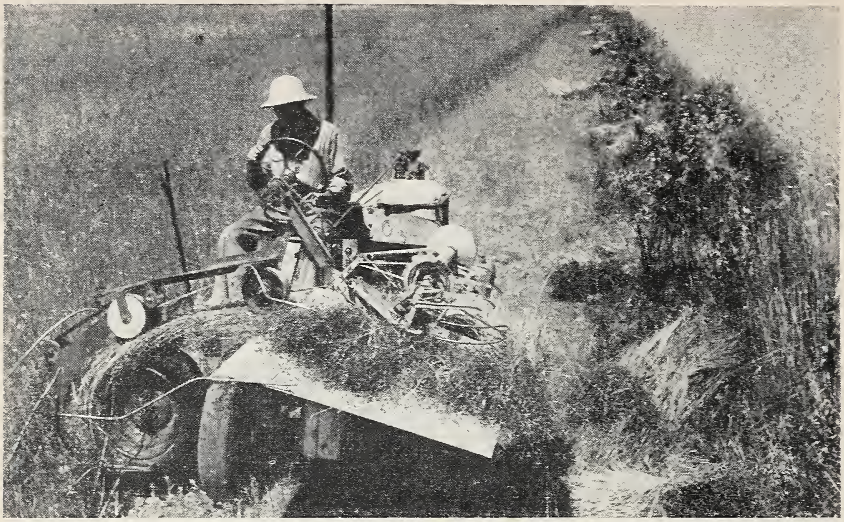

FIGURE 5.—Experimental self-propelled flax puller mounted on an automobile chassis, with a straw-gripping device consisting of a 600–16 size pneumatic tire and a rubber belt supported by a series of steel rollers forming an arc around a section of the wheel.

the binder on the left side. The unit was soon abandoned because of the difficulty caused by flax wrapping around the small-diameter pulleys and wheels (fig. 6).

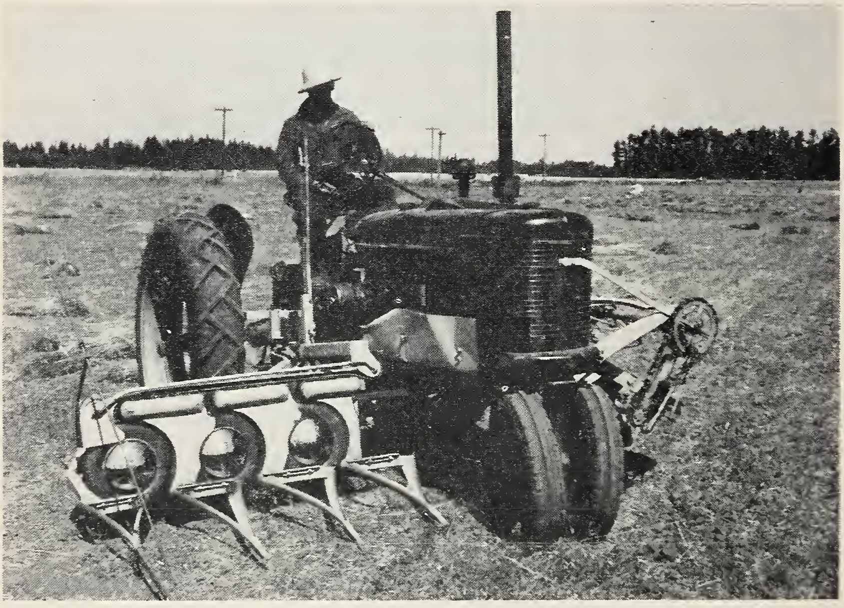

FIGURE 6.—Tractor-mounted experimental flax puller, which has 400–12 size pneumatic-tire gripping wheels and a series of flat belts backed by a curved steel slide.

A third and most successful puller of the pneumatic-tire gripping type was designed for the small farm. A single 18-inch pulling throat having a 600–16 size automobile tire and fixed rollers was the gripping device. It was tractor drawn and propelled by the tractor power takeoff. Even though the unit did a clean job of pulling, with little damage to the straw and a minimum of mechanical difficulty, only the one machine was constructed—because it had a capacity of only ½ acre per hour and formed ragged bundles. Also, a reduction of flax acreage had made many flax-pulling machines idle (fig. 7).

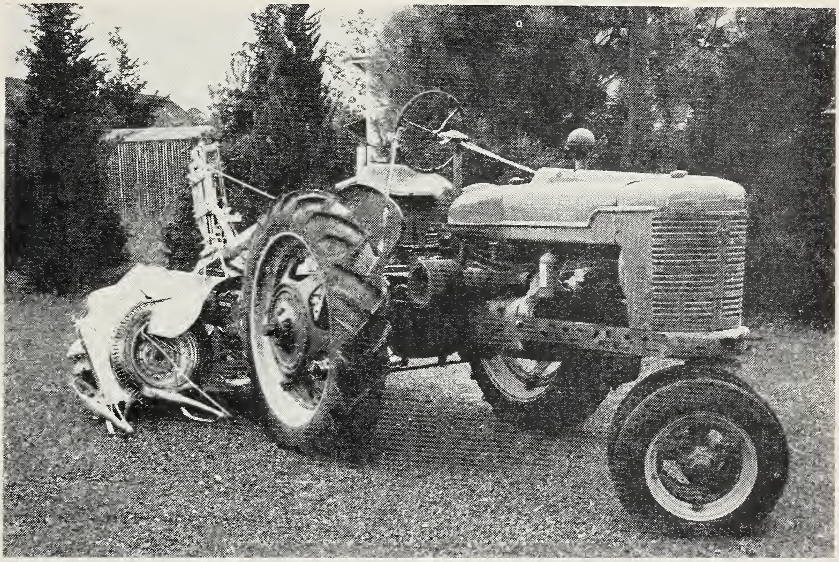

FIGURE 7.—The most successful experimental puller of the 600–16 size pneumatic tire gripping device type. It was used to harvest a considerable flax acreage but was abandoned because it had a low capacity and formed bundles with uneven root ends.

A large proportion of the flax harvested in 1942, Oregon's peak year, was pulled with Belgian- and Oregon-type machines. They are much simpler in construction and in operation than the Canadian type, but the wide pulling throats resulted in bundles with uneven straw that would not compare in neatness with those pulled by the earlier machine. The capacity of these machines was about 1 acre per hour in a 2-ton crop.

## V-belt Puller

A new puller was constructed and tested in 1945 by a local machine shop in Oregon City, Oreg. This puller was the inclined-belt, trailer type that kept the straw in a vertical position throughout the pulling operation. It differed from previous pullers in that heavy V-section transmission belts with a 1¾-inch outside face, running in grooved pulleys, were used in lieu of flat-faced pulleys and belts. The pulleys were larger in diameter and were staggered to increase the gripping pressure. The pulling belts were driven from the tractor power

takeoff through a gear box, bevel gears, spindles, and V sheaves. The V belt, supported by the V sheaves and in a 45° inclined plane, would pull flax or weeds that would normally cause flat pulling belts to run off the pulleys. The unit had two 17½-inch pulling throats and would pull more than 1½ acres of flax an hour. Little mechanical difficulty was encountered, but the machine damaged the straw at the gripping point and made many ragged, single-string bundles with uneven root ends.

## Self-Propelled Push-Type Puller

As late as 1949, farmers and managers of flax processing mills still were not satisfied with the available flax pullers. They asked the research personnel to develop a puller that would be comparable in price with the available machines and would harvest flax without damaging the straw—one that would form neat bundles with even root ends, yet have a capacity equal to or exceeding that of the existing machines, and one that would operate with a minimum of mechanical difficulty. In an effort to fulfill the request, in 1949 research engineers of the United States Department of Agriculture designed, constructed, and mounted a flax puller on a tractor (fig. 8). The unit was designed to incorporate many of the good features of previous pullers and to eliminate many of the undesirable ones, as well as to add new features.

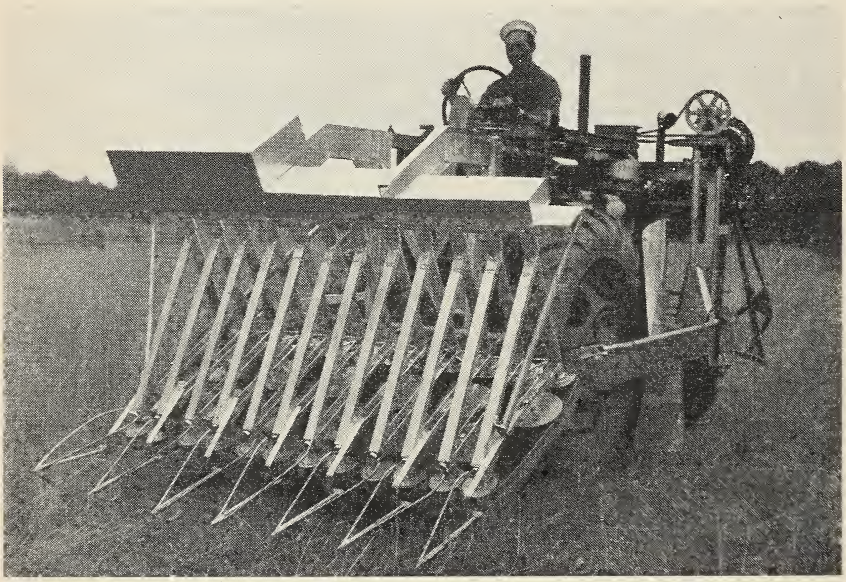

Figure 8.—Self-propelled push-type flax puller developed by research engineers of the U. S. Department of Agriculture. It has a 75-inch harvesting section consisting of six 12½-inch pulling throats. One man using this machine can harvest more than 2 acres an hour in a 2-ton crop, with minimum damage to the straw.

Among the good features of the self-propelled machine are (1) the narrow-width pulling throat and inclined-plane belt system that grips and lifts the flax out of the ground while holding it in a vertical position; (2) the large-diameter pulleys, which are staggered to give the pulling pressure and eliminate many small, troublesome spring-loaded pressure rollers; and (3) V belts and V sheaves, which permit the weeds and heavy flax to be pulled without the side pull running the belts off the drive pulleys.

Among the new features of the self-propelled puller are (1) the wide, soft-faced gripping belt that increases the area of the pulling pressure applied to the straw, thereby reducing the damage and increasing the pulling grip; (2) the low-angle incline for the pulling belts, which, in cooperation with the narrow pulling throats, harvests flax with the root ends fairly even; (3) an overhead roller chain drive for the pulling belts, which eliminates the necessity of an oiltight gear box; and (4) the train of bevel gears, which reduces the initial cost of the machine, the number of breakdowns, and cost of upkeep.

This puller also has a double-needle binder that places two strings on the straw, makes neater and more uniform bundles, and reduces straw damage and loss of straw and seed. A straw separator-stop works in conjunction with the binder to make a clean separation in the flax layer so that both ties bind the same group of straws.

An auxiliary 2,700 r. p. m., 22 hp., 4-cycle, air-cooled gasoline engine drives the pulling belts, binder, separator, and conveyor belts through a V belt, jack shaft, and gear reducers so that the pulling belts operate at a constant speed of approximately 300 feet per minute. This feature makes the belts independent of the forward speed of the tractor, allowing tractor speed to be adjusted to the density of the crop without changing the speed of the pulling belts. The pulling section exceeds the width of the tractor wheels, so that a field can be opened without running down a strip of flax and straw can be segregated in the field and weedy sections left standing, with a minimum loss of flax.

The puller is mounted on a separate frame and connected to a tractor by means of a clevis and a pin located on each side beneath the tractor axle, and by a hydraulic cylinder located at the rear of the puller. One end of the hydraulic cylinder is connected to the frame and the other end to the tractor so that the puller pivots on the pins as the plunger raises and lowers the pulling section to adjust it to the height of the crop. The transmission, steering wheel, clutch, and brakes of the tractor were altered so that it would steer and run backward, at five speeds, and push the flax-pulling unit ahead, the weight of the puller unit being supported by the large rear wheels of the tractor. The puller can be connected to or disconnected from the tractor within several hours. Thus the tractor can be used for other services before and after the flax harvest.

The new flax puller harvests a 75-inch swath into 6 throats, each 12½ inches wide. The straw is gripped between the belts and conveyed up the incline to a cross-pinned belt that combines the straw from the 6 throats into a single layer and delivers it to a pair of flat belts that in turn grip and convey the flax into a binder located near the rear of the machine. The binder is equipped with a power-driven separator-stop that holds back incoming straw while a bundle is being

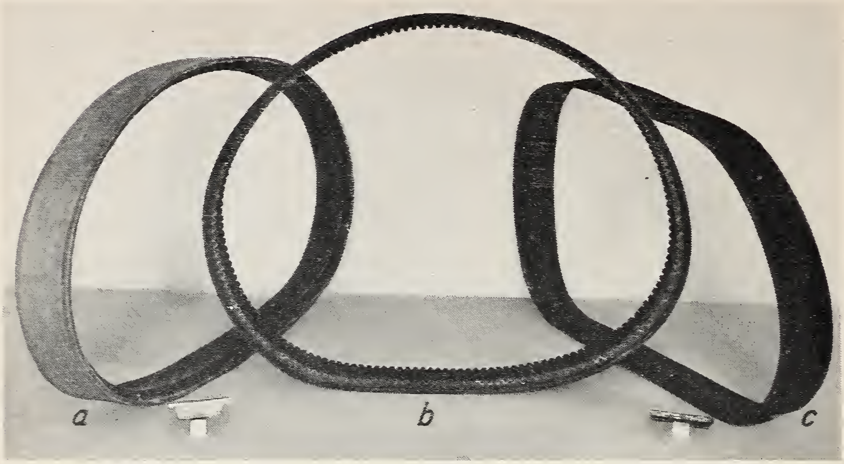


FIGURE 9.—A, Specially designed combination V and flat belt having a 1/10-inch layer of soft rubber on the 2¾-inch-wide face; B, standard, variable-speed, pulley-drive belt with edges cut to fit the special wide V sheaves; C, 4-inch-wide, 2-ply, rubber-faced, flat transmission belt.

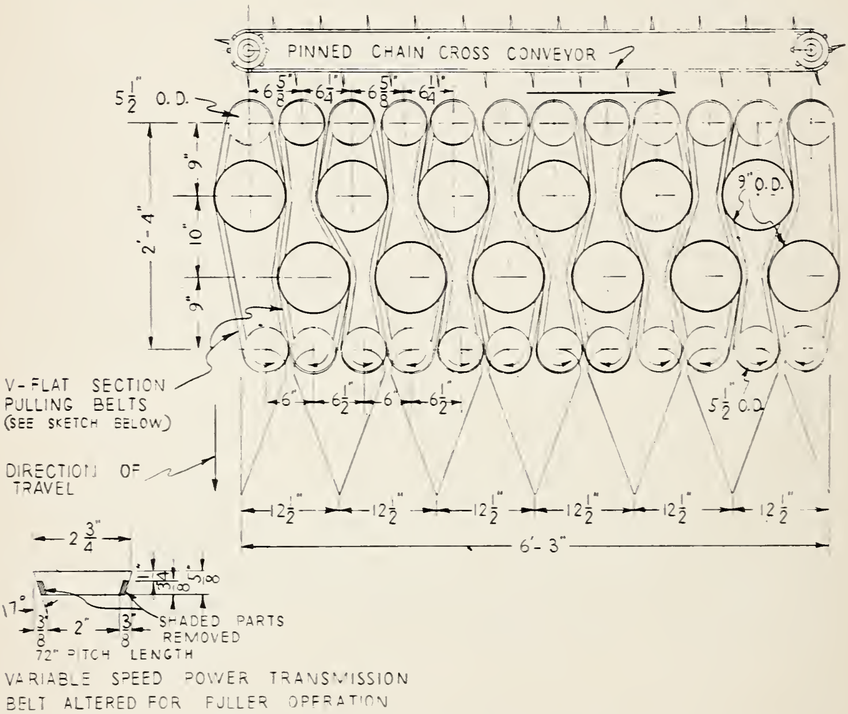


FIGURE 10.—Diagram of self-propelled puller sheave and belt arrangement.

tied with 2 strings, which are placed 12 inches apart. The pulled flax is discharged at the rear of the tractor into the harvested section of the field. In a clean field of standing flax, one man using this self-propelled puller can harvest more than 2 acres an hour in a 2-ton per acre crop.

The pulling section worked satisfactorily from the start, but after preliminary tests in 1950, 1951, and 1952 many changes were made in the conveying system and the straw separator-stop in order to eliminate wrapping and chokage. Included in the tests were types of pulling belts ranging from a 4-inch-wide, 2-ply, rubber-faced transmission belt to a specially designed combination V and flat belt having a $\frac{1}{10}$-inch layer of soft rubber on the $2\frac{3}{4}$-inch-wide face (fig. 9). Good results were obtained both with the special belts and the stock variable-speed, pulley-drive belts, but the special belts were abandoned because of their high initial cost and short life in favor of the stock belt which had grooves on the inside and a $2\frac{3}{4}$-inch, flat, rubber face on the outside. The stock belts were altered on the sides to run into the special V sheaves (figs. 10 and 11).

Approximately 25 acres were harvested during the 1951 pulling season with only minor difficulties. However, the separator-stop was strengthened and altered so that the positive drive would not damage the mechanism in case of chokage (fig. 12).

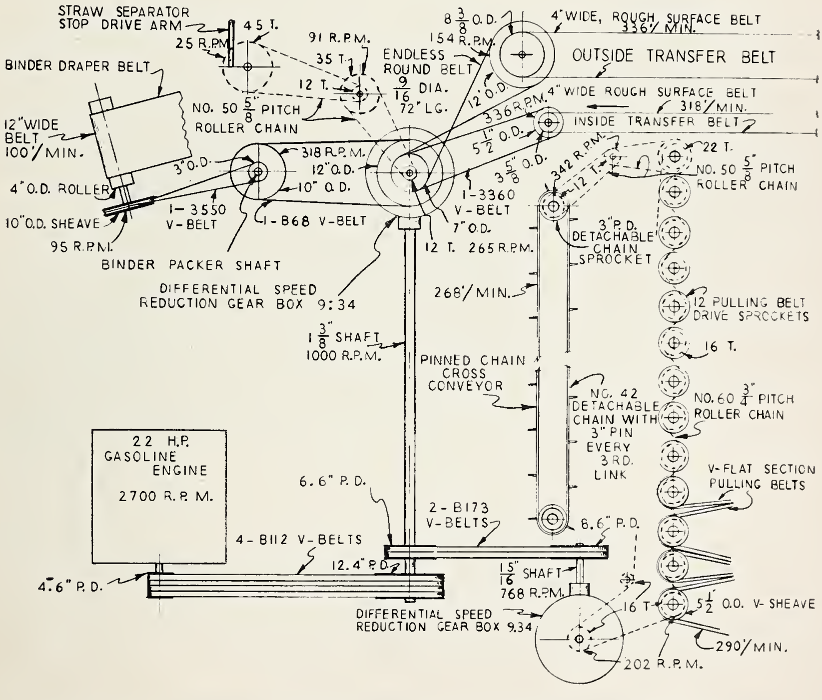


Figure 11.—Diagram of self-propelled flax puller, schematic drive plan.

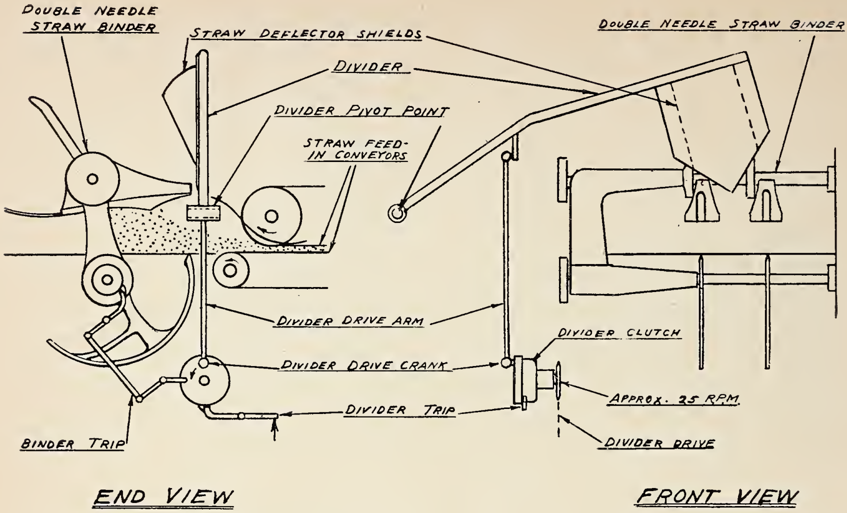


Figure 12.—Diagram of straw separator-stop.

In 1952 this self-propelled push-type puller was used to harvest approximately 70 acres of flax in 8 localities. The machine was operated largely by farmers and their hired hands. The results were most gratifying, because the puller worked under practically every possible condition in the area with very good results. Some difficulty was encountered by chokage of the binder while harvesting downed flax or flax overrun with bindweed, and by stoppage to remove wrappings from the binder. The machine was timed at pulling speeds up to 3 miles an hour in a 3-ton per acre crop.

The capacity of the puller has been limited to that of the binder. If a second binder were added, the capacity of the puller could be materially increased. It was not unusual for the machine to harvest more than 2 acres an hour in a 2-ton crop. The bundles were far superior to those harvested with other pullers and the double ties greatly reduced the straw and seed loss and damage (fig. 13).

The unit can harvest somewhat greener flax than other pullers. This is desirable because the quality of the fiber is at its best during the period in which the flax plant is changing from the green to the golden color.

The new, self-propelled flax puller is an ideal size for flax-pulling contractors and large-farm operators. However, the pulling sections are all identical and can be used in constructing any size unit, from a single 12½-inch section to a 6-section, 75-inch-wide machine. Thus, the size of the machine can be made to suit the needs of the individual farmer, whether his flax acreage be large or small.

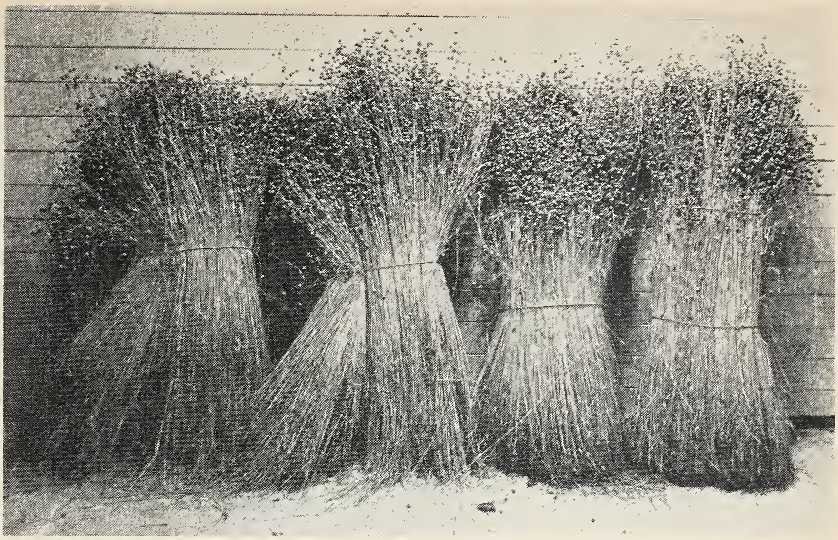

FIGURE 13.—The two bundles on the left were harvested with a commercial machine. Note the unevenness of the straw root ends and the damaged straw near the bands as compared to the evenness and undamaged straw in the bundles on the right that were harvested with the self-propelled puller.

## Summary

Fiber flax in the United States has been pulled principally by machines since the importation of the Canadian machine in 1923, yet the industry has been using many commercial and experimental machines while striving to get a puller that would harvest flax without scuffing and scarring the flax.

None of them approached the industry's requirements until the development of the self-propelled machine with narrow pulling throats, soft-faced belts, the double-string binder, and a rated capacity of 2 acres an hour in a 2-ton crop that forms far superior bundles to those formed by any of its predecessors. There is little doubt that the self-propelled puller will accelerate flax pulling and reduce the loss and damage of straw in the processing operations, resulting in higher quality fiber and increased returns to the farmer, the processor, and the spinner.

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